Harding Lawson Associates

December 13, 1991

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John D. Faught & Associates
717 Seventeenth Street, Suite 1580
Denver, CO 80202

Gentlemen:

Preliminary Evaluation of Potential
Department of Energy Radioactive Wastes
Lowry Landfill,
Arapahoe County, Colorado

In accordance with your request, Harding Lawson Associates (HLA) has reviewed the radioisotope data developed as part of the Remedial Investigation/Feasibility Study (RI/FS) for Operable Units 1 and 6 at Lowry Landfill relative to the occurrence of manmade radionuclides associated with nuclear weapons manufacturing. Specifically, we have conducted the following evaluations:

1. Identified manmade radionuclides detected in waste-pit liquid and groundwater at the site that are associated with nuclear weapons manufacturing and testing.

2. Compared the detected concentrations of these manmade radionuclides to background levels resulting from atmosphere testing as reported by EG&G for the Rocky Flats facility near Golden, Colorado.

3. Evaluated the occurrence and distribution of these manmade radionuclides relative to (1) the disposal of materials in waste pits between 1967 and 1980 and (2) pre-1967 activities at the site.

4. Conducted a preliminary qualitative assessment of the potential impacts that the occurrence of manmade radionuclides associated with wastes from nuclear weapons manufacturing may have on remedy selection and implementation.

On the basis of these evaluations, we have concluded that the occurrences of manmade radionuclides at Lowry Landfill cannot be attributed to background levels associated with atmospheric testing of nuclear weapons but are most likely associated with disposal associated with nuclear weapons manufacturing wastes at or near Lowry Landfill. From the areal and vertical distribution of the occurrence of these radionuclides, we have also concluded that their origin at the site results, in part, from activities associated with disposal in the waste pits between 1967 and 1980 and, in part, from disposal outside of the waste pit/refuse area, potentially including disposal activities conducted at or adjacent to the site before 1965. Finally, we have concluded that the presence of manmade radionuclides associated with nuclear weapons manufacturing will have a significant impact on the scope, feasibility and cost of any containment, treatment or removal actions implemented as part initial remedial measures, operable unit remedies, or a sitewide remedy. A summary of the evaluations used in developing these conclusions is presented below.

Attachment E

IDENTIFICATION OF MANMADE RADIONUCLIDES AT LOWRY LANDFILL

Radionuclide analyses were not performed during Phase I of the RI. During the first two quarters of Phase II of the RI, EPA performed gross alpha and beta analyses and gamma spectroscopy on waste-pit liquid samples and the U and B series groundwater samples and alpha spectroscopy for specific radionuclides on a few selected samples. During the third, fourth, and fifth quarters of Phase II of the RI, The Lowry Coalition performed alpha spectroscopy analyses on selected groundwater samples each quarter with the end result being that at least one groundwater sample from nearly all of the U and B series wells was analyzed by alpha spectroscopy by the completion of Phase II of the RI. During the Additional Site Characterization (ASC) effort, all of the upgradient wells were sampled and analyzed once by alpha spectroscopy. The waste-pit liquid was also sampled and analyzed once by alpha spectroscopy, and the GW-series wells, along with a few select B700-series wells, were sampled and analyzed twice by alpha spectroscopy.

From these analyses, a large number of radionuclides have been detected in waste-pit liquid, shallow groundwater, and deep groundwater at Lowry Landfill (Table 1). Currently, there are no data available relative to the occurrence and concentrations of specific radionuclides in other media (e.g., waste pit solids, landfill solids, soil, and surface water) at the site.

All radionuclides at the site are either naturally occurring or are the result of wastes from nuclear weapons manufacturing, commercial manufacturing, medical services, and/or are the daughter products resulting from radioactive decay of radionuclides contained in those wastes. The origin of certain radionuclides detected at the site cannot be readily ascertained because they could be one or more of the following: naturally occurring isotopes, decay products of naturally occurring isotopes, or decay products of manmade fission products (isotopes of transuranic elements or those with an atomic weight greater than 238).

Because the purpose of this document is to assess the likelihood that the radionuclides detected at Lowry Landfill had their origin in the manufacture of nuclear weapons, the evaluations presented in this document will focus on transuranics only.

Specifically, these evaluations will include the following:

- Americium 241 (^{241}Am)
- Plutonium 239/240 ($^{239/240}Pu$)
- Plutonium 241 (^{241}Pu)

These nuclear fission products are generally associated with the production of commercial nuclear power and the production of source materials for and the manufacturing of nuclear weapons. It is clear that wastes associated with commercial nuclear power are not the source of the transuranics detected at the site for the following reasons:

1. The radiation levels and radionuclide concentrations at the site are too low to suggest the presence of spent nuclear fuel components.

2. Most of the site disposal activities occurred between 1965 and 1980, before the generation of any spent fuel from the only nuclear power generation plant (Ft. St. Vrain) in the region. In addition, the reactor at Ft. St. Vrain is a gas-cooled reactor, and it is unlikely that cooling waters or other wastes would have been generated from that facility.

3. Storage, reprocessing, and eventual disposal of spent nuclear fuel from commercial power generation is strictly controlled by the Nuclear Regulatory Commission.

4. There is no reported record of any waste material that might contain fission products from commercial reactors having been sent to the site.

However, there is a record of waste oils and solvents having been sent to the site from the Rocky Flats facility. Because the manufacturing operations at that facility comprise fabrication of plutonium metal and other metallic parts by machining, it is likely that contaminated solvents and cutting oils comprised the largest portion of the waste stream generated at Rocky Flats.

Therefore, waste from Rocky Flats is the only credible source of the transuranics detected because of the transuranic species detected at Lowry, because there is no other plausible source of those transuranics, because they are not naturally occurring, because there is a history of the disposal of wastes from Rocky Flats at Lowry, and finally, because wastes similar to those disposed from Rocky Flats are known to contain transuranics.

EXTENT OF GROUNDWATER POTENTIALLY REQUIRING REMEDIATION

On the basis of limited sampling, manmade radionuclides have been detected offsite of Section 6 and within deep groundwater within the site. Specifically, the following observations have been noted:

1. All three of these manmade radionuclides, in particular ^{241}Am, have been detected in shallow groundwater monitoring wells located at the margins of the Superfund site.

   These wells include MW001, MW003, MW004, and MW005, MW02, MW11, MW22, MW23, U510, and B520.

2. One or more of these three radionuclides have also been detected in several deep monitoring wells (including C702P3, C702Q1, GW103, and GW113).

The occurrence of these radionuclides at the margins of the site or within deep groundwater could increase the scope and extent of any groundwater remedy that may be selected for the site.

Table 1 presents a summary of the concentrations of ^{241}Am, ^{241}Pu, and $^{239/240}Pu$ detected in waste-pit liquid, shallow groundwater, and deep groundwater at Lowry Landfill. Table 1 also presents the range of concentrations of these elements in background groundwater at the U.S. Department of Energy's (DOE) Rocky Flats Plant. The background values reported for Rocky Flats are the only available published background levels for these compounds. Comparison of the background levels of these radionuclides as defined by EG&G for the Rocky Flats facility to the levels of these same radionuclides detected at Lowry Landfill indicates that the levels of

^{241}Am and $^{239/240}Pu$ detected at Lowry Landfill are 10 to 10,000 times greater than the average or maximum background levels reported for Rocky Flats. Therefore, the occurrence of these radionuclides at Lowry Landfill cannot be attributed to background levels associated with aboveground, atmospheric testing of nuclear weapons. Comparisons of the concentrations of ^{241}Pu cannot be made because EG&G did not report a background level(s) for ^{241}Pu at Rocky Flats.

Occurrence and Distribution of Manmade Radionuclides at Lowry Landfill

Americium-241 and $^{239/240}Pu$ were detected in the waste-pit liquid and shallow groundwater (OU 1) and the deep groundwater (OU 6) operable units at Lowry Landfill. Plutonium-241 was not detected in the waste-pit liquid but was detected in shallow and deep groundwater at the site. All three of these radionuclides were also detected in the upgradient wells at Lowry at concentrations 50 to 5000 times greater than background levels reported for Rocky Flats.

Distribution of Manmade Radionuclides within the Waste Pit/Refuse Area

Plutonium-241 was not detected in waste-pit liquid, however, it was detected in five shallow groundwater monitoring wells completed within the waste-pit area. Americium-241 was detected in six waste-pit well points and one shallow monitoring well within the source area. Plutonium 239/240 were detected in 5 waste-pit well points and 11 shallow groundwater monitoring wells within the waste-pit area.

The occurrence of these radionuclides is dominated by two general areas at the site: (1) the northwest portion of the waste pit/refuse area in waste-pit well points WP003 and WP701 and shallow groundwater monitoring wells U704 and B704 and (2) the central portion of the waste pit/refuse area in waste-pit well points WP002, WP7008, and WP101A and shallow monitoring wells U706, B706, U707, U710, B710, and U711. These two areas are dominated by waste pits that were used for disposal between 1976 and 1980. According to Rockwell's 104e responses, this period coincides with the period during which waste oils and solvents from Rocky Flats were disposed of at Lowry Landfill.

These three radionuclides were also detected in the following areas:

1. Southeast and east central portion of the waste pit/refuse area (WP709, WP712, U702, and U703)
2. North and north central portion of the waste pit/refuse area (WP715 and WP716)
3. Along Unnamed Creek (WP007, WP718, and U504)
4. In shallow groundwater wells at the toe of the landfill (U503, U712, and GW112)

The waste pits in the southeast/east central area in which these manmade radionuclides are present were used for disposal from 1977 to 1979. Waste pits in the north/north central area that contain these manmade radionuclides were used for disposal between 1974 and 1977 (WP716) and in 1980 (WP715). The timeframes in which these waste pits were used for disposal is the

same timeframe over which wastes from Rocky Flats were reportedly disposed of at Lowry Landfill.

The waste pits located along Unnamed Creek that contain these manmade radionuclides were used for disposal in 1970. This period is before the timeframes when Rocky Flats reported waste shipments to Lowry Landfill. However, we understand that Rocky Flats records documenting waste shipments to unknown recipients in the 1969 to 1970 timeframe. Therefore, occurrences of manmade radionuclides in these waste pits is consistent with an origin associated with Rocky Flat's wastes.

The occurrence of manmade radionuclides in shallow groundwater at the toe of the landfill cannot be attributed to any particular timeframe. This area collects leachate and shallow groundwater from a large portion of the waste pit/refuse area.

Distribution of Manmade Radionuclides Relative to Pre-1967 Activities at the Site

As previously indicated, manmade radionuclides, principally ^{241}Am, were detected in all eight of the upgradient shallow groundwater monitoring wells of Lowry Landfill. Indications of a pre-1967 waste disposal along the south boundary of the site are a likely source for the occurrences of manmade radionuclides in the upgradient shallow groundwater monitoring wells at Lowry Landfill. Specifically, the following observations have been noted on the basis of a review of aerial photographs of the site and historical information:

1. Both the 1950 and 1956 aerial photographs of the area clearly show a surface disturbance of the south boundary of the site, to the west of the former location of Unnamed Creek and immediately to the east of upgradient well U510, which contains ^{241}Am at 1.7 pCi/l.

2. The 1963 aerial photograph (Figure 1) clearly indicates the presence of a constructed facility consisting of an access road, perimeter road, enclosing fence, gate, and constructed pond containing liquid. This facility was located at the south margin of the site at the head of a small tributary to Murphy Creek in the area of the current upgradient monitoring well MW22. Well MW22 contains high levels of ^{241}Am (pCi/l) and ^{241}Pu (21 pCi/l).

3. Former Colorado State patrolman, W. H. Wilson, has reported that tanker trucks from Rocky Flats disposed of liquid along Quincy and Gun Club Roads at the site during the early 1960s. This report coincides with the occurrence of ^{241}Am and other manmade radionuclides in the eight upgradient shallow monitoring wells located to the south and southwest of the site along Quincy and Gun Club Roads.

IMPACT OF MANMADE RADIONUCLIDES ON POTENTIAL REMEDIES AT LOWRY LANDFILL

The occurrence at Lowry Landfill of nuclear weapons-related radionuclides at concentrations substantially above background levels is anticipated to impact the selection, scope, and cost of potential remedies for waste pits and groundwater at Lowry in the following three ways:

1. Achievement of applicable or relevant and appropriate requirements (ARARs)
2. Management of residuals
3. Volume and extent of groundwater potentially requiring remediation

Achievement of ARARs

At this time, three potential chemical-specific ARARs have been identified relative to manmade radionuclides. These include (1) NRC Standards for Protection Against Radiation (10 CFR Part 20 et al.), (2) Colorado Primary Drinking Water Standards 5CCR1003-1, and (3) Colorado Basic Standards for Groundwater (5 CCR 1002-8).

The NRC standards would restrict effluent limitations for discharges to water for ^{241}Am and $^{239/240}$Pu to 20 pCi/l each and for ^{241}Pu to 1000 pCi/l. The concentrations of ^{241}Am in GW112 (94 pCi/l) and $^{239/240}$Pu in U504 (21 pCi/l) exceed these standards.

Colorado Primary Drinking Water Regulations have set a maximum contaminant level for beta particle and photon radioactivity from manmade radionuclides in community water systems at levels such that an annual dose equivalent to the total body or any internal organ shall not exceed 4 millirems per year (mrem/year). EPA has indicated (1986) that concentrations of ^{241}Am of 4 pCi/l or ^{239} Pu of 40 pCi/l yield a risk equal to that from a dose rate of 4 mrem/year. The concentrations of ^{241}Am in upgradient shallow groundwater monitoring wells MW003 and MW22 exceed this level. The concentrations of ^{241}Am in GW112 (94 pCi/l) and MW11 (5.1 pCi/l) also exceed this level.

Finally, Colorado has established a standard for $^{239/240}$Pu in groundwater of 15 pCi/l. The concentrations of $^{239/240}$Pu in wells U504 and MW11 exceed this level.

As a result of these evaluations, remediation to reduce the levels of radionuclides in shallow groundwater may be required. In addition, any discharge of treated water from the site may require additional treatment to meet these ARARs.

Management of Residuals

Any treatment alternatives at the site will result in the generation of hazardous residuals, some of which may contain concentrated levels of manmade radionuclides. Currently, no permitted commercial or DOE facility exists that can accept mixed wastes containing both hazardous constituents and radionuclides, regardless of their origin. Two DOE facilities currently provide the capacity for the 'temporary' storage of mixed wastes: the Low Level Waste Management Facility at the Nevada Test Site and the Idaho National Engineering Laboratory. The only other potential repository for transuranics from nuclear weapons productions is the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico. While WIPP is intended to store and manage defense wastes from the DOE complex, and while it may eventually receive mixed wastes, the date for the opening of the facility has been postponed indefinitely for a variety of technical, legal, and administrative reasons.

999-6-0060-A0006

Finally, because the expected concentrations of transuranic elements and other radionuclides in the residuals generated during remediation at Lowry cannot be qualitatively estimated until the ongoing treatability studies are completed, it is unknown whether these wastes could be accepted at a commercial low-level radioactive waste disposal facility.

CONCLUSIONS

On the basis of the data obtained to date as part of the remedial investigation/feasibility study (RI/FS) for the shallow and deep groundwater OUs at Lowry, the following conclusions with respect to manmade transuranic radionuclides can be made:

1. Manmade radionuclides associated with nuclear weapons production are present in the shallow groundwater at Lowry Landfill at concentrations 10 to 10,000 times background levels.

2. On the basis of the nature and occurrence of these radionuclides, their origin at Lowry Landfill strongly appear to be the result of pre-1967 waste disposal activities at Lowry and disposal of Rocky Flats wastes during 1975 to 1980 and possibly earlier.

3. The occurrence of these radionuclides could have a significant impact on the ability of potential remedial alternatives to achieve ARARs and the costs associated with residuals managements and groundwater collection and treatment.

We appreciate the opportunity to assist you with this effort. Please contact either of us to discuss the data used to develop this evaluation or the resultant conclusions.

Sincerely,

HARDING LAWSON ASSOCIATES

Neil J. Myers for

Brian D. LaFlamme
Senior Geochemist

Paul V. Rosasco
Senior Vice President

PVR/BDL/EL/rn
Attachments

Attachment 1

Table 1: Concentration Ranges of Manmade Radionuclides

	Waste-Pit Well Points	Monitoring Wells Within Source Area	Monitoring Wells Outside Source Area	Upgradient Monitoring Wells	Deep Monitoring Wells	Rocky Flats
Plutonium - 239/240	0.58 - 9.2	0.42 - 21.0	0.17 - 45.0	0.59	0.09 - 0.60	0.011 - 0.004
Plutonium - 241	ND	9.7 - 150	14.0 - 18.0	21.0 - 78.0	1.5 - 24.0	NR
Americium - 241	1.4 - 4.0	94.0	0.22 - 10.0	1.3 - 13.0	0.31 - 0.66	-0.003 - 0.009

Concentrations are in picocuries per liter.

ND = not detected
NR = not reported

999-6-0060-A0009

Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

12/06/91

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
B502	Americium-241 (alpha)	01/15/91	0.2000	U		O	25961	0.0000
B502	Americium-241 (alpha)	03/12/91	0.3000	U		O	31559	0.0000
B502	Plutonium-241	01/15/91	0.2000	U		O	25961	0.0000
B502	Plutonium-241	03/12/91	20.0000	U		O	31559	0.0000
B502	Plutonium-239/240	07/12/89	0.6600			O	72418	0.4400
B502	Plutonium-239/240	01/15/91	0.3000	U		O	25961	0.0000
B502	Plutonium-239/240	03/12/91	0.3000	U		O	31559	0.0000
B504	Americium-241 (alpha)	12/10/90	0.2000	U		R	22892	0.0000
B504	Americium-241 (alpha)	12/10/90	0.3000	U		F	22893	0.0000
B504	Americium-241 (alpha)	01/07/91	0.3000	U		O	24885	0.0000
B504	Americium-241 (alpha)	01/07/91	0.3000	U		R	24886	0.0000
B504	Plutonium-241	12/10/90	25.0000	U		F	22893	0.0000
B504	Plutonium-241	12/10/90	27.0000	U		R	22892	0.0000
B504	Plutonium-241	01/07/91	77.0000	U		O	24885	0.0000
B504	Plutonium-241	01/07/91	77.0000	U		R	24886	0.0000
B504	Plutonium-239/240	12/10/90	0.1000	U		F	22893	0.0000
B504	Plutonium-239/240	12/10/90	0.1600			R	22892	0.1300
B504	Plutonium-239/240	01/07/91	1.0000	U		R	24886	0.0000
B504	Plutonium-239/240	01/07/91	0.2000	U		O	24885	0.0000
B518	Americium-241 (alpha)	08/28/90	9.0000	U	J	O	13106	0.0000
B518	Plutonium-241	08/28/90	38.0000	U		O	13106	0.0000
B518	Plutonium-239/240	08/28/90	0.2000	U	J	O	13106	0.0000
B519	Americium-241 (alpha)	08/28/90	4.0000	U		O	13100	0.0000
B519	Americium-241 (alpha)	08/28/90	1.8000			R	13097	0.4000
B519	Plutonium-241	08/28/90	24.0000	U		O	13100	0.0000
B519	Plutonium-241	08/28/90	24.0000	U		R	13097	0.0000
B519	Plutonium-239/240	08/28/90	0.2000	U		R	13097	0.0000
B519	Plutonium-239/240	08/28/90	0.1000	U		O	13100	0.0000
B520	Americium-241 (alpha)	09/11/90	0.2000	U		O	14620	0.0000
B520	Plutonium-241	03/31/89	78.0000			O	HLA-01063	40.00
B520	Plutonium-241	09/11/90	25.0000	U		O	14620	0.0000
B520	Plutonium-239/240	03/31/89	0.5900			O	HLA-01063	0.32
B520	Plutonium-239/240	09/25/89	0.3000	U		O	79046	
B520	Plutonium-239/240	09/11/90	0.2000	U		O	14620	0.0000
B521	Plutonium-241	03/28/89	300.0000	U		O	HLA-01256	

Concentrations in picocuries per liter
1 = indicates detection or nondetection (U) of radionuclide
4 = data qualifiers
6 = original (O), replicate (R), or stagnant (F) sample

Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

12/06/91

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
B521	Plutonium-239/240	03/28/89	0.9000	U		O	HLA-01256	
B521	Plutonium-239/240	09/19/89	0.8000	U		O	78444	
B704	Plutonium-241	04/07/89	97.0000			O	HLA-01725	70.00
B704	Plutonium-239/240	04/07/89	1.3000			O	HLA-01725	0.70
B704	Plutonium-239/240	07/19/89	0.6000	U		O	72971	
B704	Plutonium-239/240	09/27/89	0.4000	U		R	79197	
B704	Plutonium-239/240	09/27/89	0.3000	U		O	79196	
B705	Plutonium-239/240	07/12/89	0.0800	U		O	72416	
B706	Plutonium-239/240	07/18/89	0.4000	U		O	72888	
B707	Plutonium-239/240	07/17/89	0.9500			O	72889	0.5200
B708	Plutonium-239/240	07/11/89	0.1000	U		O	72368	
B708	Plutonium-239/240	09/22/89	0.2000	U		R	78676	
B708	Plutonium-239/240	09/22/89	0.1000	U		O	78675	
B709	Plutonium-239/240	07/12/89	0.8200			O	72417	0.3800
B710	Plutonium-241	04/06/89	76.0000			O	HLA-01804	43.00
B710	Plutonium-239/240	04/06/89	0.5800			O	HLA-01804	0.51
B710	Plutonium-239/240	07/21/89	4.0000			O	73152	0.4000
B710	Plutonium-239/240	07/21/89	0.9400			R	73151	0.6400
B710	Plutonium-239/240	09/27/89	0.1000	U		O	79194	
B711	Plutonium-239/240	07/11/89	0.4000	U		O	72367	
B712	Americium-241 (alpha)	01/10/91	0.4000	U		O	25952	0.0000
B712	Americium-241 (alpha)	02/28/91	20.0000	U		O	30041	0.0000
B712	Plutonium-241	01/10/91	30.0000	U		O	25952	0.0000
B712	Plutonium-241	02/28/91	40.0000	U		O	30041	0.0000
B712	Plutonium-239/240	09/13/88	3.0000	U		O	MHM300	
B712	Plutonium-239/240	07/06/89	0.3000	U		O	71665	
B712	Plutonium-239/240	09/21/89	1.0000	U		O	78622	
B712	Plutonium-239/240	01/10/91	0.4000	U		O	25952	0.0000

Concentrations in picocuries per liter
1 = indicates detection or nondetection (U) of radionuclide
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Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

12/06/91

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
B712	Plutonium-239/240	02/28/91	0.0600	U		O	30041	0.0000
C702P3	Plutonium-241	03/23/89	24.0000			O	HLA-01015	12.00
C702P3	Plutonium-239/240	09/27/88	0.3000	U		O	MHM310F	
C702P3	Plutonium-239/240	03/23/89	0.2250			O	HLA-01015	0.10
C702Q1	Plutonium-239/240	09/28/88	1.4000			R	MHM309	
C702Q1	Plutonium-239/240	09/28/88	0.6000			O	MHM307F	
C702Q1	Plutonium-239/240	09/13/89	0.0500	U		O	78127	
GW101	Americium-241 (alpha)	04/24/91	0.0800	U		O	36514	0.0000
GW101	Plutonium-241	04/24/91	10.0000	U		O	36514	0.0000
GW101	Plutonium-239/240	04/24/91	0.1700			O	36514	0.1500
GW102	Americium-241 (alpha)	01/04/91	0.2000	U		O	24887	0.0000
GW102	Plutonium-241	01/04/91	30.0000	U		O	24887	0.0000
GW102	Plutonium-239/240	01/04/91	0.1000	U		O	24887	0.0000
GW103	Americium-241 (alpha)	01/08/91	0.6600			O	25594	0.3900
GW103	Americium-241 (alpha)	05/10/91	0.4200	U		O	38656	0.0000
GW103	Plutonium-241	01/08/91	100.0000	U		O	25594	0.0000
GW103	Plutonium-241	05/10/91	8.0000	U		O	38656	0.0000
GW103	Plutonium-239/240	01/08/91	0.2000	U		O	25594	0.0000
GW103	Plutonium-239/240	05/10/91	0.0900			O	38656	0.1500
GW104	Americium-241 (alpha)	01/15/91	1.0000	U		O	25960	0.0000
GW104	Americium-241 (alpha)	02/26/91	0.2600			O	29765	0.2400
GW104	Plutonium-241	01/15/91	50.0000	U		O	25960	0.0000
GW104	Plutonium-241	02/26/91	40.0000	U		O	29765	0.0000
GW104	Plutonium-239/240	01/15/91	0.2000	U		O	25960	0.0000
GW104	Plutonium-239/240	02/26/91	0.2000	U		O	29765	0.0000
GW106	Americium-241 (alpha)	01/09/91	0.5000	U		R	25592	0.0000
GW106	Americium-241 (alpha)	01/09/91	0.5000	U		O	25590	0.0000
GW106	Americium-241 (alpha)	02/21/91	0.5000	U		O	29473	0.0000
GW106	Americium-241 (alpha)	02/21/91	0.6000	U		R	29474	0.0000
GW106	Plutonium-241	01/09/91	50.0000	U		O	25590	0.0000
GW106	Plutonium-241	01/09/91	40.0000	U		R	25592	0.0000
GW106	Plutonium-241	02/21/91	40.0000	U		O	29473	0.0000

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1 = indicates detection or nondetection (U) of radionuclide
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6 = original (O), replicate (R), or stagnant (F) sample

Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

12/06/91

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
GW106	Plutonium-241	02/21/91	50.0000	U		R	29474	0.0000
GW106	Plutonium-239/240	01/09/91	0.3000	U		O	25590	0.0000
GW106	Plutonium-239/240	01/09/91	0.2000	U		R	25592	0.0000
GW106	Plutonium-239/240	02/21/91	0.2000	U		O	29473	0.0000
GW106	Plutonium-239/240	02/21/91	0.0800	U		R	29474	0.0000
GW107A	Americium-241 (alpha)	02/20/91	0.4000	U		O	29267	0.0000
GW107A	Plutonium-241	01/08/91	140.0000	U		O	25159	0.0000
GW107A	Plutonium-241	02/20/91	300.0000	U		O	29267	0.0000
GW107A	Plutonium-239/240	01/08/91	0.5000	U		O	25159	0.0000
GW107A	Plutonium-239/240	02/20/91	0.9000	U		O	29267	0.0000
GW108A	Americium-241 (alpha)	03/05/91	0.1000	U		O	30433	0.0000
GW108A	Plutonium-241	03/05/91	50.0000	U		O	30433	0.0000
GW108A	Plutonium-239/240	03/05/91	0.1000	U		O	30433	0.0000
GW109	Americium-241 (alpha)	01/08/91	0.7000	U		O	25157	0.0000
GW109	Americium-241 (alpha)	02/20/91	0.3000	U		O	29268	0.0000
GW109	Plutonium-241	01/08/91	26.0000	U		O	25157	0.0000
GW109	Plutonium-241	02/20/91	50.0000	U		O	29268	0.0000
GW109	Plutonium-239/240	01/08/91	0.4000	U		O	25157	0.0000
GW109	Plutonium-239/240	02/20/91	0.2000	U		O	29268	0.0000
GW110A	Americium-241 (alpha)	01/03/91	1.0000	U		O	24779	0.0000
GW110A	Americium-241 (alpha)	03/04/91	0.5000	U		O	30496	0.0000
GW110A	Plutonium-241	01/03/91	56.0000	U		O	24779	0.0000
GW110A	Plutonium-241	03/04/91	20.0000	U		O	30496	0.0000
GW110A	Plutonium-239/240	01/03/91	0.2000	U		O	24779	0.0000
GW110A	Plutonium-239/240	03/04/91	0.3000	U		O	30496	0.0000
GW111	Americium-241 (alpha)	01/08/91	4.0000	U		O	25156	0.0000
GW111	Americium-241 (alpha)	02/22/91	8.0000	U		O	29764	0.0000
GW111	Plutonium-241	01/08/91	40.0000	U		O	25156	0.0000
GW111	Plutonium-241	02/22/91	30.0000	U		O	29764	0.0000
GW111	Plutonium-239/240	01/08/91	0.2000	U		O	25156	0.0000
GW111	Plutonium-239/240	02/22/91	0.0700	U		O	29764	0.0000
GW112	Americium-241 (alpha)	01/09/91	94.0000			O	25596	80.0000
GW112	Americium-241 (alpha)	02/27/91	30.0000	U		O	29993	0.0000
GW112	Plutonium-241	01/09/91	70.0000	U		O	25596	0.0000

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999-6-0060 -A0009

Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

12/06/91

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
GW112	Plutonium-241	02/27/91	50.0000	U		O	29993	0.0000
GW112	Plutonium-239/240	01/09/91	3.1000			O	25596	1.8000
GW112	Plutonium-239/240	02/27/91	0.1000	U		O	29993	0.0000
GW113	Americium-241 (alpha)	01/04/91	0.3100			O	24888	0.2300
GW113	Americium-241 (alpha)	03/06/91	0.5700			O	30736	0.2600
GW113	Plutonium-241	01/04/91	110.0000	U		O	24888	0.0000
GW113	Plutonium-241	03/06/91	40.0000	U		O	30736	0.0000
GW113	Plutonium-239/240	01/04/91	0.4000	U		O	24888	0.0000
GW113	Plutonium-239/240	03/06/91	0.1000	U		O	30736	0.0000
GW114A	Americium-241 (alpha)	01/09/91	0.3000	U		O	25598	0.0000
GW114A	Americium-241 (alpha)	03/01/91	0.2000	U		O	30497	0.0000
GW114A	Plutonium-241	01/09/91	20.0000	U		O	25598	0.0000
GW114A	Plutonium-241	03/01/91	40.0000	U		O	30497	0.0000
GW114A	Plutonium-239/240	01/09/91	0.3000	U		O	25598	0.0000
GW114A	Plutonium-239/240	03/01/91	0.6000	U		O	30497	0.0000
MW001	Americium-241 (alpha)	01/14/91	0.5000	U		O	25956	0.0000
MW001	Americium-241 (alpha)	03/08/91	0.2000	U		O	31109	0.0000
MW001	Plutonium-241	01/14/91	70.0000	U		O	25956	0.0000
MW001	Plutonium-241	03/08/91	14.0000			O	31109	8.0000
MW001	Plutonium-239/240	01/14/91	0.5000	U		O	25956	0.0000
MW001	Plutonium-239/240	03/08/91	0.0700	U		O	31109	0.0000
MW002	Plutonium-241	03/28/89	800.0000	U		O	HLA-00865	
MW002	Plutonium-239/240	03/28/89	1.3000	U		O	HLA-00865	
MW003	Americium-241 (alpha)	08/30/90	4.6000			O	13414	1.2000
MW003	Plutonium-241	08/30/90	38.0000	U		O	13414	0.0000
MW003	Plutonium-239/240	08/30/90	0.3000	U		O	13414	0.0000
MW004	Americium-241 (alpha)	08/29/90	1.3000			O	13230	0.3000
MW004	Plutonium-241	08/29/90	29.0000	U		O	13230	0.0000
MW004	Plutonium-239/240	08/29/90	0.1000	U		O	13230	0.0000
MW005	Americium-241 (alpha)	08/30/90	1.9000			O	13418	0.4000
MW005	Plutonium-241	08/30/90	21.0000	U		O	13418	0.0000
MW005	Plutonium-239/240	08/30/90	0.1000	U		O	13418	0.0000

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Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
MW02	Americium-241 (alpha)	01/23/91	0.2000	U		O	26906	0.0000
MW02	Americium-241 (alpha)	03/14/91	0.2200			O	31560	0.1700
MW02	Plutonium-241	01/23/91	60.0000	U		O	26906	0.0000
MW02	Plutonium-241	03/14/91	20.0000	U		O	31560	0.0000
MW02	Plutonium-239/240	01/23/91	0.9000	U		O	26906	0.0000
MW02	Plutonium-239/240	03/14/91	0.1000	U		O	31560	0.0000
MW10	Americium-241 (alpha)	01/24/91	0.6000	U		O	26986	0.0000
MW10	Americium-241 (alpha)	03/13/91	0.3000	U		O	31561	0.0000
MW10	Plutonium-241	01/24/91	40.0000	U		O	26986	0.0000
MW10	Plutonium-241	03/13/91	20.0000	U		O	31561	0.0000
MW10	Plutonium-239/240	01/24/91	0.6000	U		O	26986	0.0000
MW10	Plutonium-239/240	03/13/91	0.1000	U		O	31561	0.0000
MW11	Americium-241 (alpha)	01/24/91	0.5000	U		O	26987	0.0000
MW11	Americium-241 (alpha)	01/24/91	0.1000	U		R	26985	0.0000
MW11	Americium-241 (alpha)	03/15/91	0.4900		JB*	R	32083	0.2300
MW11	Americium-241 (alpha)	03/15/91	10.0000		JB*	O	32084	1.0000
MW11	Plutonium-241	01/24/91	50.0000	U		O	26987	0.0000
MW11	Plutonium-241	01/24/91	200.0000	U		R	26985	0.0000
MW11	Plutonium-241	03/15/91	11.0000	U	J*	R	32083	11.0000
MW11	Plutonium-241	03/15/91	11.0000	U	J*	R	32083	0.0000
MW11	Plutonium-239/240	01/24/91	0.8000	U		O	26987	0.0000
MW11	Plutonium-239/240	01/24/91	0.8000	U		R	26985	0.0000
MW11	Plutonium-239/240	03/15/91	45.0000		J*	O	32084	2.0000
MW11	Plutonium-239/240	03/15/91	8.9000		J*	R	32083	0.7000
MW22	Americium-241 (alpha)	09/04/90	13.0000			O	13618	6.0000
MW22	Plutonium-241	09/04/90	21.0000			O	13618	15.0000
MW22	Plutonium-239/240	09/04/90	0.2000	U		O	13618	0.0000
MW23	Americium-241 (alpha)	01/25/91	0.0900	U		O	27323	0.0000
MW23	Americium-241 (alpha)	03/13/91	0.0700	U		O	31562	0.0000
MW23	Plutonium-241	01/25/91	50.0000	U		O	27323	0.0000
MW23	Plutonium-241	03/13/91	18.0000			O	31562	11.0000
MW23	Plutonium-239/240	01/25/91	0.8000	U		O	27323	0.0000
MW23	Plutonium-239/240	03/13/91	0.0500	U		O	31562	0.0000
U503	Plutonium-241	04/03/89	150.0000			O	HLA-01517	120.00

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Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
U503	Plutonium-239/240	09/06/88	14.0000			O	MHM517	
U503	Plutonium-239/240	04/03/89	4.5000			O	HLA-01518	0.9
U504	Plutonium-241	04/05/89	200.0000	U		O	HLA-01648	
U504	Plutonium-241	04/05/89	60.0000	U		R	HLA-01621	
U504	Plutonium-239/240	09/02/88	21.0000			O	MHM283	
U504	Plutonium-239/240	04/05/89	0.2500	U		O	HLA-01648	
U504	Plutonium-239/240	04/05/89	1.0450			R	HLA-01621	0.33
U509	Americium-241 (alpha)	08/30/90	2.3000			O	13422	0.5000
U509	Plutonium-241	08/30/90	26.0000	U		O	13422	0.0000
U509	Plutonium-239/240	08/30/90	0.2000	U		O	13422	0.0000
U510	Americium-241 (alpha)	09/05/90	1.7000			O	13765	0.7000
U510	Plutonium-241	03/15/89	20.0000	U		O	HLA-00944	
U510	Plutonium-241	09/05/90	20.0000	U		O	13765	0.0000
U510	Plutonium-239/240	03/15/89	0.5000	U		O	HLA-00944	
U510	Plutonium-239/240	07/05/89	0.3000	U		O	71446	
U510	Plutonium-239/240	09/12/89	0.4000	U		O	78126	
U510	Plutonium-239/240	09/05/90	0.1000	U		O	13765	0.0000
U518	Americium-241 (alpha)	08/28/90	3.0000	U		O	13091	0.0000
U518	Plutonium-241	08/28/90	24.0000	U		O	13091	0.0000
U518	Plutonium-239/240	08/28/90	0.0800	U		O	13091	0.0000
U701	Plutonium-239/240	09/13/89	0.1000	U		O	78128	
U702	Plutonium-241	04/11/89	100.0000	U		O	HLA-01752	
U702	Plutonium-239/240	08/25/88	50.0000	U		R	MHM269	
U702	Plutonium-239/240	08/25/88	50.0000	U		O	MHM268	
U702	Plutonium-239/240	04/11/89	0.9950			O	HLA-01752	0.46
U702	Plutonium-239/240	07/24/89	0.5000	U		O	73182	
U702	Plutonium-239/240	07/24/89	0.4000	U		R	73183	
U702	Plutonium-239/240	09/28/89	2.8000			O	79314	1.3000
U703	Plutonium-241	04/12/89	60.0000	U		O	HLA-01777	
U703	Plutonium-239/240	04/12/89	0.9600			O	HLA-01777	0.50
U703	Plutonium-239/240	09/29/89	0.0600	U		O	79451	

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Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
U704	Plutonium-241	04/07/89	50.0000			O	HLA-01700	27.0
U704	Plutonium-239/240	08/25/88	20.0000	U		O	MHM273	
U704	Plutonium-239/240	04/07/89	1.2000			O	HLA-01674	0.5
U704	Plutonium-239/240	04/07/89	0.2000	U		R	HLA-01700	
U704	Plutonium-239/240	07/20/89	0.8600			O	73059	0.3800
U704	Plutonium-239/240	09/27/89	0.0500	U		O	79195	
U706	Plutonium-241	04/04/89	61.0000			O	HLA-01544	50.00
U706	Plutonium-239/240	04/04/89	1.0000			O	HLA-01545	0.5
U706	Plutonium-239/240	07/19/89	0.4000	U		O	73058	
U706	Plutonium-239/240	09/18/89	0.0400	U		O	78443	
U707	Plutonium-241	03/13/89	80.0000	U		O	HLA-00840	
U707	Plutonium-239/240	03/13/89	0.4250			O	HLA-00840	0.23
U707	Plutonium-239/240	07/10/89	0.6000	U		R	72366	
U707	Plutonium-239/240	07/10/89	0.5900			O	72365	0.5100
U707	Plutonium-239/240	09/25/89	0.2000	U		O	79047	
U710	Plutonium-241	04/04/89	200.0000	U		O	HLA-01594	
U710	Plutonium-239/240	04/04/89	0.9200			O	HLA-01594	0.70
U710	Plutonium-239/240	07/13/89	0.1000	U		O	72595	
U710	Plutonium-239/240	09/20/89	1.0000	U		O	78623	
U711	Plutonium-241	03/31/89	200.0000	U		O	HLA-01442	
U711	Plutonium-239/240	03/31/89	1.4500			O	HLA-01442	0.60
U711	Plutonium-239/240	07/14/89	0.1000	U		O	72596	
U712	Plutonium-241	03/30/89	200.0000	U		O	HLA-01467	
U712	Plutonium-239/240	03/30/89	1.0750			R	HLA-01492	0.55
U712	Plutonium-239/240	03/30/89	0.9800			O	HLA-01467	0.60
U712	Plutonium-239/240	07/20/89	0.8500			O	73057	0.7400
U712	Plutonium-239/240	09/15/89	2.0000	U		O	78153	
WP001	Americium-241 (alpha)	01/11/91	3.0000	U		O	25951	0.0000
WP001	Plutonium-241	01/11/91	60.0000	U		O	25951	0.0000
WP001	Plutonium-239/240	01/11/91	1.0000	U		O	25951	0.0000
WP002	Americium-241 (alpha)	01/14/91	5.0000	U		O	25957	0.0000

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999-6-0060-A0009

Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
WP002	Plutonium-241	01/14/91	37.0000	U		O	25957	0.0000
WP002	Plutonium-239/240	01/14/91	0.7700			O	25957	0.6800
WP003	Americium-241 (alpha)	01/22/91	1.4000			O	26744	0.6000
WP003	Plutonium-239/240	01/22/91	1.0000	U		O	26744	0.0000
WP007	Americium-241 (alpha)	01/22/91	1.7000			O	26745	0.7000
WP007	Plutonium-241	01/22/91	83.0000	U		O	26745	0.0000
WP007	Plutonium-239/240	01/22/91	1.0000	U		O	26745	0.0000
WP101A	Americium-241 (alpha)	01/25/91	1.8000			O	27322	0.9000
WP101A	Plutonium-241	01/25/91	26.0000	U		O	27322	0.0000
WP101A	Plutonium-239/240	01/25/91	0.6000	U		O	27322	0.0000
WP102	Americium-241 (alpha)	01/24/91	8.0000	U		O	26983	0.0000
WP102	Plutonium-239/240	01/24/91	5.0000	U		O	26983	0.0000
WP701	Americium-241 (alpha)	01/18/91	5.0000	U		R	26535	0.0000
WP701	Americium-241 (alpha)	01/18/91	4.0000			O	26536	2.3000
WP701	Plutonium-239/240	01/18/91	26.0000			R	26535	11.0000
WP701	Plutonium-239/240	01/18/91	2.0000	U		O	26536	0.0000
WP702	Americium-241 (alpha)	01/09/91	3.0000	U		O	25600	0.0000
WP702	Plutonium-239/240	01/09/91	10.0000	U		O	25600	0.0000
WP703	Americium-241 (alpha)	01/10/91	4.0000	U		O	25606	0.0000
WP703	Plutonium-241	01/10/91	110.0000	U		O	25606	0.0000
WP703	Plutonium-239/240	01/10/91	2.0000	U		O	25606	0.0000
WP707	Americium-241 (alpha)	01/04/91	3.0000	U		O	25155	0.0000
WP707	Plutonium-239/240	01/04/91	10.0000	U		O	25155	0.0000
WP708	Americium-241 (alpha)	01/17/91	4.0000	U		O	26230	0.0000
WP708	Plutonium-241	01/17/91	260.0000	U		O	26230	0.0000
WP708	Plutonium-239/240	01/17/91	9.2000			O	26230	4.7000

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Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
WP709	Americium-241 (alpha)	01/14/91	1.0000	U		O	25959	0.0000
WP709	Plutonium-241	01/14/91	26.0000	U		O	25959	0.0000
WP709	Plutonium-239/240	01/14/91	0.5900			O	25959	0.5600
WP710	Americium-241 (alpha)	01/16/91	4.0000	U		O	26215	0.0000
WP710	Plutonium-241	01/16/91	32.0000	U		O	26215	0.0000
WP710	Plutonium-239/240	01/16/91	0.4000	U		O	26215	0.0000
WP711	Americium-241 (alpha)	01/09/91	0.2000	U		O	25602	0.0000
WP711	Plutonium-241	01/09/91	50.0000	U		O	25602	0.0000
WP711	Plutonium-239/240	01/09/91	0.3000	U		O	25602	0.0000
WP712	Americium-241 (alpha)	01/08/91	2.4000		J*	O	25160	1.6000
WP712	Americium-241 (alpha)	01/08/91	6.0000	U	J*	R	25158	0.0000
WP712	Plutonium-241	01/08/91	150.0000	U		R	25158	0.0000
WP712	Plutonium-241	01/08/91	87.0000	U		O	25160	0.0000
WP712	Plutonium-239/240	01/08/91	0.6000	U		R	25158	0.0000
WP712	Plutonium-239/240	01/08/91	0.5000	U		O	25160	0.0000
WP713	Americium-241 (alpha)	01/07/91	0.7000	U		O	24884	0.0000
WP713	Plutonium-241	01/07/91	100.0000	U		O	24884	0.0000
WP713	Plutonium-239/240	01/07/91	0.6000	U		O	24884	0.0000
WP714	Americium-241 (alpha)	01/21/91	0.5000	U		O	26538	0.0000
WP714	Plutonium-241	01/21/91	40.0000	U		O	26538	0.0000
WP714	Plutonium-239/240	01/21/91	0.3000	U		O	26538	0.0000
WP715	Americium-241 (alpha)	01/11/91	7.0000	U		O	25953	0.0000
WP715	Plutonium-241	01/11/91	39.0000	U		O	25953	0.0000
WP715	Plutonium-239/240	01/11/91	0.5800			O	25953	0.5700
WP716	Americium-241 (alpha)	01/10/91	7.0000	U		O	25608	0.0000
WP716	Plutonium-241	01/10/91	71.0000	U		O	25608	0.0000
WP716	Plutonium-239/240	01/10/91	1.5000			O	25608	1.4000
WP717	Plutonium-239/240	01/15/91	1.0000	U		O	25962	0.0000

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999-6-0060-A0009

Historical Summary of Lowry Landfill Man-made Radionuclides
(Americium-241, Plutonium-241, Plutonium-239/240)

Location	Radionuclide	Sample Date	Value	1	4	6	Traffic Number	Counting Error
WP718	Americium-241 (alpha)	01/23/91	4.2000			O	26905	2.7000
WP718	Plutonium-239/240	01/23/91	3.0000	U		O	26905	0.0000
WP720	Americium-241 (alpha)	01/17/91	0.7000	U		O	26229	0.0000
WP720	Plutonium-239/240	01/17/91	1.0000	U		O	26229	0.0000

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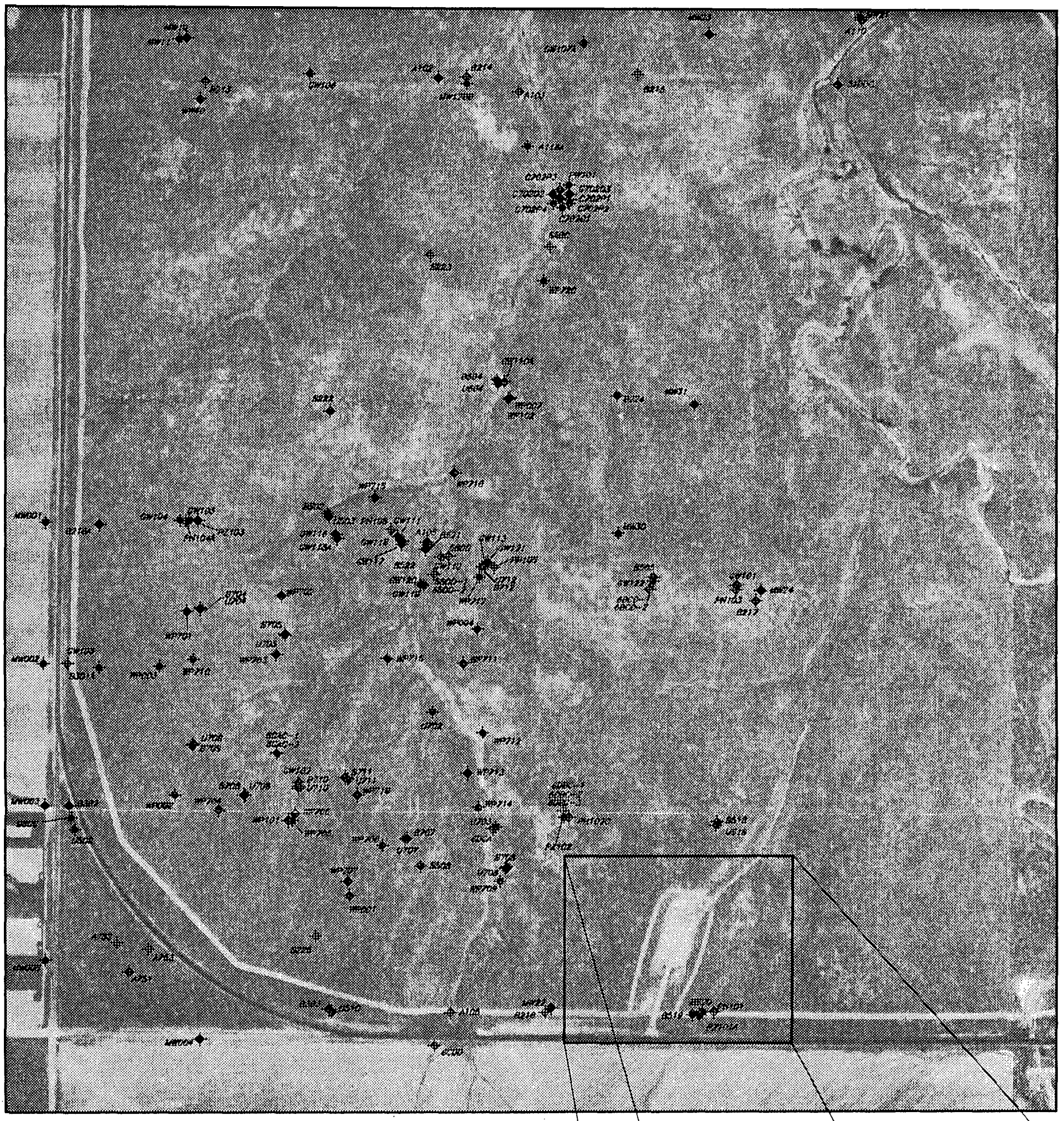
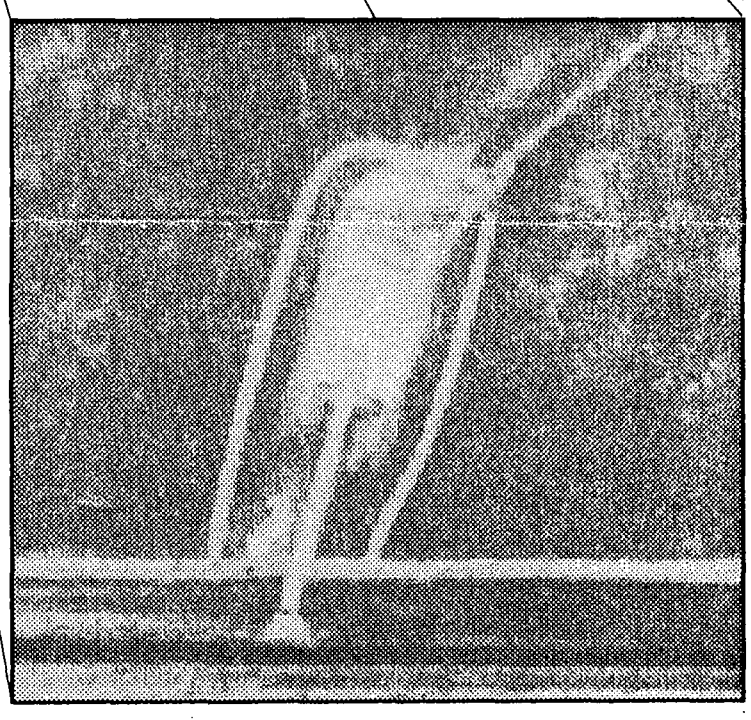
1 = indicates detection or nondetection (U) of radionuclide
4 = data qualifiers
6 = original (O), replicate (R), or stagnant (F) sample

999-6-0060-A0010

LOW 1223





N

0 300 600

Approximate scale in feet

Suspected Disposal Facility

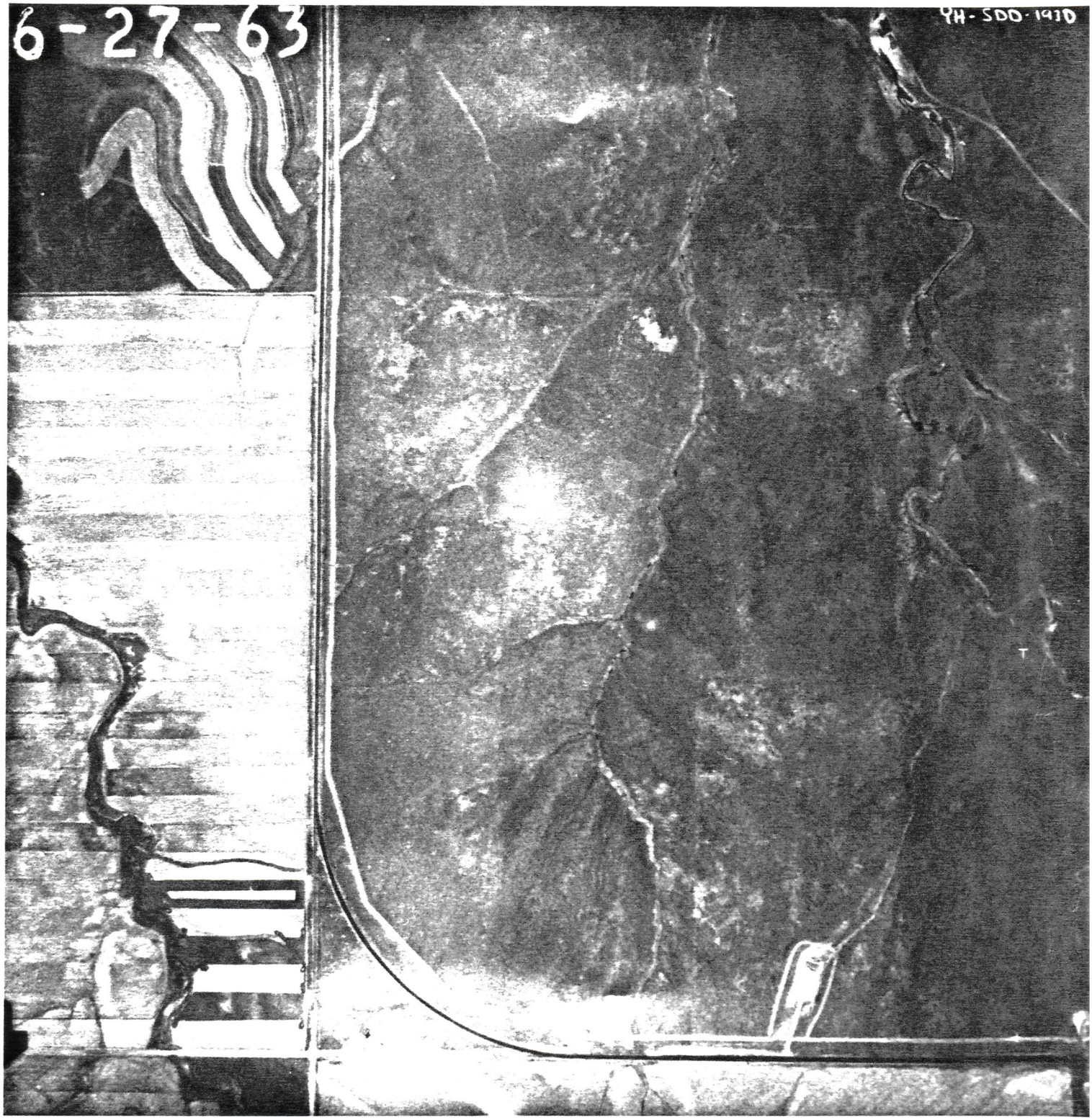
Harding Lawson Associates
Engineering and Environmental Services

Suspected Disposal Facility Shown on 1963 Aerial Photograph
Lowry Landfill
Arapahoe County, Colorado

FIGURE **1**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED DATE
ACL	18876,058.10		12/91	

999-6-0060-A0011



Attachment F